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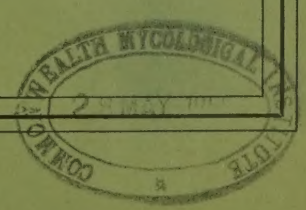

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REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

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Tomato Breeding

LEWIS A. DARBY

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TOMATOES were introduced into Britain in the sixteenth century, but only during the last eighty years have they ceased to be a curiosity and become a popular part of the nation's diet. Although not grown under glass for marketing until 1880, about two-thirds of the 4,600 acres of horticultural glass in England and Wales are now devoted to this crop.

In eighty years, many principles of heredity have been established, and genetical science has made many contributions to plant breeding. The tomato industry has also been affected by changes in the nation's economic structure, the consequences of repeated cropping under intensive cultivation, and foreign competition. Methods used to breed new varieties have varied. Since the tomato was introduced, the genetic system on which seed production is based has been modified from outbreeding to inbreeding, changed back to outbreeding with F_1 hybrids, and now veers towards inbreeding again. New techniques such as irradiation, embryo culture, interspecific hybridization and polyploidy are used, but some of the most useful variants now being developed were discovered by growers as chance mutants in commercial crops. Breeding work on British glasshouse tomatoes is the main subject of this article.

Early Selections

The character selected as the most important was the ability to set fruit by natural pollination in England's climate and growing conditions, without insects to pollinate the fruit. This choice resulted in the style becoming enclosed within the anther cone rather than protruding like its South American ancestors. Consequently, the breeding system of English tomatoes was changed from partly outbreeding to 100 per cent inbreeding. No great physiological depression of the plants resulted, but the move towards homozygosis enabled the subsequent selection of different pure breeding lines. As the demand for tomatoes increased, growers and seedsmen produced new improved varieties by hybridizing and selecting, and more glasshouses were erected in different parts of Britain. Even more new names were bestowed on these varieties but it has been possible to classify them into distinct groups [1]. It has been the practice, after the introduction of a new variety, for each grower to select a strain claimed to be particularly suited to his own nursery. This selection could only be possible if, before its release, the original variety had not been sufficiently inbred and selected to eliminate all variability, or if there were a high mutation rate in the genes controlling adaptability.

*Now at the Glasshouse Crops Research Institute.

Growing Conditions

In Britain, where there is a wide range of climates, soil types, glasshouse designs and cropping systems, it is unlikely that one variety of tomatoes will be satisfactory for cultivation in all areas. The N.A.A.S. Experimental Horticulture Stations play an important part in breeding projects by conducting large-scale and randomized trials under a wide range of growing conditions.

Most breeding work has been devoted to glasshouse crops, but some attention has been given to the selection of outdoor varieties. *Puck* was bred as an early maturing type of upright habit with the inflorescences borne close together [2]. The strong vertical stem keeps the heavy crop clear of the ground, thus reducing the losses due to fungal and bacterial attack, as well as preventing the fruit from being blemished by mud spots.

In the United States many varieties have been produced for use in extreme conditions, such as the short, dry growing season of North Dakota or the very high temperatures of the Southern States. Wet season tolerance is the aim in the West Indies and Nigeria. Many countries have selected frost-resistant types by seedling treatment in refrigerators and by field trials.

Marketing Considerations

Tomatoes, compared with most crops, have a high production cost per plant. They are an annual crop and a large plant yield must be obtained in the 20-week harvesting period. Time of production is very important, because unlike most temperate agricultural crops, tomatoes are marketed for consumption immediately after picking. An early crop is the most valuable, for as the season progresses there are increasing supplies from heated and unheated glass, outdoor crops, imports and backgarden plants. Demand also falls when tree fruits are in plentiful supply. An early variety which ripens in April and May contributes to the value of the total national crop; a good price can be obtained for the early fruit, which avoids the overladen market of late summer. Not all nurseries are suited to early cropping, so there is little chance of over-production merely being brought forward to an earlier time of the year. Fruit size and shape must conform to the marketing scheme requirements; in addition, the plant breeder must select for flavour and freedom from physiological blemishes such as blotchy ripening, bronzing, greenback and cracking. Selling points, such as brightness of fruit and a large calyx are also important. Breeding programmes at research stations in other countries are concerned with vitamins A and C content, dry matter percentage, firmness, and suitability for canning.

Characteristics

Yield per plant can be resolved into the following component characters: number of trusses, fruits per truss, locules per fruit and weight per locule. These characters can be analysed further, e.g., the number of fruits per truss depends on the number of flowers differentiated, the number reaching maturity, pollen production, pollination, and the growth of the ovary after fertilization. Earliness can be initially resolved into the time intervals between sowing, germination, flower opening, fruit setting and fruit ripening. Numerous genetical studies [3, 4, 5, 6, 7, 8] of these characters have revealed the multiplicity and the complex interactions of the controlling genes. The latter may result in beneficial or non-beneficial heterosis dependent on the character and the genotypes being studied. Most workers have concluded that the greatest progress in breeding for yield and earliness can be made by utilizing F_1 hybrids.

Some specialist growers aim at producing winter fruit, but the main obstacle is poor pollen production under conditions of short days and low light intensity. When *Lycopersicum esculentum*, the cultivated tomato, is crossed with the related wild species, *L. pimpinellifolium*, those lines derived from the hybrid with *L. esculentum* as female parent are able to set fruit in winter conditions [9]. This winter-fruiting habit is being introduced into a commercial variety by means of a backcross programme.

Fruit shape is determined by several genes, of which the most important is that controlling locule number. The dominant allele results in even-shaped bilocular fruit, compared with the variable multi-locular fruit produced by the recessive allele. Pear shape, nipple tip, flattened shape and extreme fasciation, which are determined by other recessive genes, are not desirable characters. No investigations have been made on the developmental process which often results in the malformation of the first fruit on each truss. The even-ripening character of the "Stonors" varieties, which are free from greenback, is determined by a single recessive gene.

It is not known to what extent the reputed loss of flavour of English tomatoes is due to intensive selection for other characters such as yield. One cause might be the early picking necessitated by the marketing system, or the increasing use of fertilizers and sprays.

Disease Resistance

Widespread and intensive cultivation of tomatoes has led to increased losses due to pests and diseases. Much can be done to control these by good hygiene and by chemical methods, but the primary use of genetic resistance does seem to be a cheaper and more efficient method.

There has been extensive screening of material for disease resistance in the United States [10] where 144 wild species and varieties were tested for resistance to 16 different pathogens. *L. peruvianum* and *L. pimpinellifolium* were shown to be sources of resistance to many

diseases, and the survey also confirmed the existence of physiological races in some disease organisms.

Much attention has been given to the leaf mould fungus *Cladosporium fulvum* which causes considerable losses in areas of high humidity. New resistant varieties have been produced by crossing a commercial variety with a resistant species or variety, and subsequently selecting to combine commercial qualities and leaf mould resistance. *Vetomold* was bred in Canada from a cross involving *L. pimpinellifolium*, and in Britain *Antimold A* was selected from *Potentate* crossed with *Leaf Mould Resister No.* 1.

There are several loci in tomato at which the dominant alleles confer either immunity or resistance to one or more of the physiological races of *Cladosporium*. One consequence of introducing genes for disease resistance into a host is to favour mutant races of the pathogen which can overcome this resistance. With *Cladosporium* the effect of this increased specialization by the pathogen is to reduce its ability to compete with the original race on a variety susceptible to both races. A survey [11] shows that most isolates of these specialized races came from Lancashire and Wales—areas where the disease is most prevalent, and where new resistant varieties are grown extensively. The sequence of Canadian varieties *Vetomold*, *V*121, *V*473 and *Vulcan*, which have different genes for resistance, is similar to that of the numerous rust-resistant wheat varieties which have been produced. It remains to be seen for how long the latest introduction, *Vagabond*—which incorporates resistance to all the known races of leaf mould—will remain free from attack.

It has been suggested [12] that the easy establishment of new races of some parasites is related to the fact that resistance is only controlled by single major genes which may be readily overcome by mutations in the pathogen. Information is required on the reaction of wild species to new mutant races able to overcome resistance due to single major genes which has been transferred from wild species into commercial varieties. When breeding for leaf mould resistance, it may be better to transfer modifiers as well as major genes from the wild species into the genetic background of the commercial varieties.

The use of multiple gene resistance in one variety rather than the introduction of genes, one at a time, into a series of new varieties, appears to be the best way of utilizing genetic resistance. Because of the combined actions of the resistance genes, the potential number of new races which could establish themselves is reduced. Many of these races could only arise by double or more complex mutations, though some might result from single mutations.

Attempts have been made in the laboratory [11] to produce new physiological races of *Cladosporium* by X-ray or ultra-violet light radiation. If this could be readily achieved then it might be possible to breed for resistance to races which had not yet become established in glasshouses.

A possible way of controlling leaf mould is to vary the genes for resistance each year so that the build-up of any race of fungus is prevented. This can best be done by a scheme now being developed [13]. The two parents of a commercially desirable hybrid are being bred in a backcross programme so that each exists as several lines. The lines of any one parent are to be alike in combining ability, but will differ in their genes for resistance. It should then be possible, by selecting the correct parental lines, to produce the hybrid with resistance to the leaf mould races which threaten at any time and place. The commercial qualities of the hybrid should be constant.

Surveys have been made for resistance to the stem rot fungus *Didymella lycopersici*. Inoculation tests of five species and thirty varieties [14] failed to reveal any useful material. In another trial [15] of 40 genotypes, only two species showed resistance to soil infection, but these were susceptible to wound inoculation.

American workers are investigating wild material resistant to tobacco mosaic, but the occurrence of new strains of a virus may be even more troublesome than the origin of physiological races in fungi. Breeding programmes for resistance to many other diseases, mainly of outdoor tomatoes, are in progress ; one of these programmes includes attempts to induce resistance to late blight by X-ray and other ionizing radiations.

Labour-Saving Mutants

Labour and fuel are now very expensive items in the cost of producing a tomato crop. Mutants which require less cultivation, less heat for forcing, or can utilize nutrients more efficiently are of great potential value.

The short-jointed mutants, e.g., *Baby Lea* selected from the variety *Potentate*, with their compact growth have certain advantages over the vigorous, spreading varieties. It is easier to move amongst the plants and less time is required for training the stems.

Another very interesting mutant is "suppressed lateral" which arose spontaneously in "*Antimold B*" [16]. Absence of side shoots in tomatoes would reduce labour demands, limit the spread of virus on pruning knives, and lessen the number of wounds by which *Botrytis* may enter the plant. Unfortunately, unfruitfulness due to floral abnormalities is associated with "suppressed lateral". It is not yet known whether these two characters are pleiotropic expressions of one recessive gene, or the expressions of tightly-linked genes. Crosses with many other species and varieties are being made to see whether, in a different genetic background, the gene may affect the side shoots alone and allow the flowers to develop normally [17]. If the characters are controlled by tightly-linked genes then they might be separated by X-ray or temperature shock at neiosis.

A bad flavour is produced in canned tomatoes and juice if the calyx and stalk are processed with the fruit, and time has to be spent at harvesting to ensure that these are removed. The mutant "jointless"

has no knuckle to the flower stalk so the stalk and calyx remain on the plant when the fruit is picked. Canadian plant breeders are trying to incorporate this character in good commercial varieties [18].

Hybrid Tomatoes

Tomato varieties are inbred lines derived from the original outbreeding population which was introduced from South America. F_1 hybrids which are obtained by cross-pollination of these inbred lines sometimes exhibit heterosis for commercial characters, especially earliness [19], and are a convenient way of combining desirable qualities. Much attention is now devoted to these hybrids in tomato-breeding projects.

It is usually impossible to predict the combining abilities of varieties, and large-scale trials, as in the development of Hertford Cross and Ware Cross [20], are necessary to expose the best hybrid combinations.

The genetic mechanism of heterosis is not fully understood. One theory is that inbred lines possess different dominant genes and that these are all brought together in the F_1 generation. The failure to retain all these dominant genes in a pure-breeding variety is attributed to the tight linkages between dominant and recessive genes at different loci, which prevent the necessary recombinations. The theory of overdominance postulates that heterosis depends solely on heterozygosis, and that it is the divergence in function of allelomorphs which results in the superiority of the F_1 hybrid. From a study of heterosis for earliness in the tomato it has been suggested [19] that the time of gene action is important, and that, in a hybrid, genes from different parents control development at different stages of plant growth.

There is an inverse relationship between the temperature at truss differentiation and the number of flowers produced. F_1 hybrids have been shown to be more stable for this character than their inbred parents [21]. When families were raised at high and low temperatures, the character was expressed more constantly in the hybrid than in the parent. Phenotypic stability, in spite of environmental variation, is a very useful attribute for crop plants. It extends the area of cultivation, reduces the effects of climatic variation, and facilitates prediction of yield.

Seed Production

Each crop of F_1 hybrids has to be raised from first-cross seed produced by cross-pollination. Flowers on the female parent have to be emasculated by hand, and pollen has to be transferred to the stigmas from the anthers of the male parent. This makes hybrid seed more expensive than seed saved from an inbreeding variety. In order to minimize this extra cost, male sterility is being bred into several varieties which are to be used as female parents for producing hybrid seed [13]. A recessive gene prevents anther dehiscence and the pollen is not released. The style is being lengthened by selection so that it just reaches the tip of the anther cone. Emasculation is unnecessary,

and cross-pollination is facilitated. Two recessive marker genes, green stem and potato leaf, are also being included. These lines are pure breeding and seed can be readily obtained if the anthers are burst and the flowers self-pollinated. By using a pollen parent with the corresponding dominant genes, all of the F_1 hybrids are purple stem, cut leaf and with normal self-pollinating flowers. If, in the F_1 planting, there are any seedlings which result from accidental self-pollination of the female parent they can be detected by their green stem and potato leaf, and can be discarded. F_2 families can also be readily identified. Due to the segregation of these unlinked genes, each of the recessive characters would reappear independently in 25 per cent of the F_2 plants. There would, of course, also be variability in the commercial characters of these F_2 plants.

A similar project in the United States [22] has reported loss of combining ability due to the introduction of these genes. This is an unexpected result which cannot be readily explained. One suggested reason is that selection in the early part of the backcross programme was too vigorous.

Another recessive male sterile mutant which is being studied in Canada [23] has only vestigial anthers. Plants grown in winter develop normal anthers with viable pollen, so that this line can also be propagated by seed.

It has been shown [24] that the increased yield of an F_2 population is approximately half the increment obtained from the F_1 hybrid, when both are compared with the yield of the inbred parents. F_2 seeds are cheaper, but a male sterile type cannot be used to produce the original F_1 hybrid, because a quarter of the F_2 plants would be homozygous for the recessive gene determining male sterility, and they would be unfruitful. In countries with large field plantings where yield per plant is low, F_2 crops may be economic; but for intensive cultivation under glass in Britain, where it is estimated [20] that an increase of 0.1 per cent of the crop yield will pay for the extra cost of hybrid seed, F_1 crops are preferable. Variability between the plants in F_2 populations would be very troublesome if the cultural requirements of the original parental varieties differed.

Work is also in progress [25] to fix transgressive segregants out of the F_2 populations from good F_1 hybrids. This would be a return to pure-breeding varieties and the advantages of simpler seed production.

It has been demonstrated [13, 26] that the segregation ratios from heterozygous material can be modified by reduced pollination, or by the elimination of gametes with slow pollen tube growth. This has an important bearing on breeding programmes especially in backcrossing, for it suggests that the homozygous recurrent genotype should be used as the pollen parent. All the pollen grains would be genetically identical and the loss of variability due to stylar selection would be avoided.

Polyploidy and Parthenocarpy

Tetraploid tomatoes can be produced either by cutting back diploids and propagating adventitious buds in the callus, or by colchicine treatment. They are of little use commercially, because meiotic irregularity leads to lowered fertility, and the reduced seed set results in small fruit with less juice. The absence of seed and juice from parthenocarpic fruit is a reason against using hormone sprays for crop production.

Future Aims

Research stations have been giving increasing attention to the tomato, both as an experimental plant and as an economic crop. In 1949, it was estimated [27], that 40 tons of fruit had to be picked to cover the cost of production per acre. This is a high proportion of the average crop; furthermore, in six years there have been large increases in labour and fuel costs. Although there may be many formulae for the perfect tomato, in his ultimate selection the plant breeder has to compromise, bearing in mind both the relative merits of different characters, and the need to maintain tomato-growing as a paying proposition.

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The Bacteriology of Farm Water Supplies

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THE QUALITY OF WATER needed on farms should be related to what is required for specific purposes. Savage [1] has suggested how our water resources could be used, based upon knowledge of how infections are spread through milk, or directly to stock. Wells or streams free from visible pollution can be satisfactory for stock drinking water, but ponds are usually grossly contaminated and have no advantages. For washing down cowsheds, milk parlours and dairy premises, any reasonably clean water will do, without need for bacteriological examination. But a pure supply should, if possible, always be used for domestic purposes, for milk coolers, and for washing all surfaces likely to come into direct contact with milk.

A recent survey [2] showed that, of 155,000 English and Welsh holdings registered for milk production, only 50 per cent had a piped supply of water from public service mains. Of the remainder, 37 per cent depended on other sources including deep wells, privately pumped; 11 per cent used shallow wells, brooks, or even ponds; and 2 per cent had water carted. The position is probably worse on holdings where milk is not produced.

Piped water is now becoming available to an increasing number of farms, but unless proper arrangements can be made for the disposal of waste water, the faster movement of polluted water towards the

sources of supply will give less opportunity for pathogenic organisms to die out. Water circulation will be speeded up and, without adequate safeguards, the provision of adequate supplies may well lead to fresh outbreaks of disease [3]. Many people do not realize that crude sewage is treated principally to prevent the effluent from causing a nuisance, or silting up the river or stream into which it is discharged; treatment is not intended to act as a disinfecting process.

It will be some time before all rural areas can be supplied with piped water, and it is doubtful if such supplies could be made available to every farm. As a result, supplies must continue to be developed and their quality assessed.

Public Health Aspects

The consequences of an undetected major pollution of a water supply serving a large number of consumers may be disastrous. The distribution of similarly infected raw milk can be equally disastrous; milk being ideal for the growth of micro-organisms, whereas water, at the most, only permits their survival in ever-diminishing numbers [4]. The fact that milk provides an efficient medium for bacterial growth means that once-daily collections allow a period of approximately 12 hours for bacterial multiplication. The original infecting dose of organisms need not be large—under suitable conditions, a large volume of milk could be infected by the small amount of polluted water which might remain on dairy utensils after cleansing.

Organisms of typhoid, paratyphoid, dysentery and gastro-enteritis are the most serious obstacles to the provision and maintenance of a safe water supply. Recent studies suggest that these organisms are more frequent and survive longer in stream water, than was originally thought possible. Infection with members of the salmonella (food poisoning) group of organisms is not uncommon in domestic and farm animals, and the bacilli may occur in considerable numbers in dung. It seems reasonable to suppose, therefore, that water can be infected with salmonella organisms, and isolations have, in fact, been made.

Sources of Pollution

Though by far the greater number of recorded epidemics of milk-borne enteric fever resulted from direct contamination of the milk by a human carrier, the literature relates many cases of indirect infection by means of a polluted water supply used either in the dairy for the cleansing of utensils or for the rinsing of containers.

An outbreak of paratyphoid fever in 1946 involving 45 people was found to be due to the use of heavily contaminated water for the final rinsing of bottles immediately before filling with pasteurized milk. The water had been chlorinated, but the period of contact was insufficient since the process was carried out rather irregularly [5].

In 1953, a widespread outbreak of food poisoning occurred which affected at least 252 people. All were supplied with milk from a

particular farm. Isolations of *salmonella typhi-murium* were made from the dung of a single cow and from some of the milk handlers, and it is reasonable to suppose that contamination of the dairy water had occurred [6].

Human excreta may contain pathogenic organisms derived from enteric and dysentery carriers, capable of surviving treatment of the crude sewage and persisting both in the effluent and for a considerable distance from the point of discharge. Paratyphoid organisms have been found to persist in septic tank liquid for over 60 days, and in well water for over 50 days [7]. While there is no evidence that cattle are susceptible to infection with typhoid, paratyphoid or dysentery bacilli, the risk of fouled flanks and udders should not be underestimated as a source of infection.

Bacteriological Tests

Isolation of pathogenic organisms from the excreta of disease carriers and those affected is not difficult, and improved methods have simplified the isolation of specific pathogenic micro-organisms from crude sewage and sewage effluent. However, the water bacteriologist cannot yet rely on detection of these organisms to guide his assessment of the purity of a supply because of the high dilution of sewage contaminating a water supply. Instead, he searches for the normal inhabitants of the intestine, the presence of which indicates faecal pollution. Of the common intestinal bacteria, Bact. coli I is the most characteristic, and is so abundant in faeces that its absence from 100 ml. of a sample of water justifies the presumption that pathogenic organisms are also absent. Incubation at 44° C instead of 37° C in MacConkey broth has proved to be almost completely specific for this organism and its presence can thus be estimated quantitatively as a routine measure. Occasionally false positives occur and modifications have been suggested to give even greater sensitivity [10]. Because of their longer persistence, other organisms, such as *Streptococcus faecalis*, have been suggested as being more reliable indicators of excretal contamination than Bact. coli I [11]. The methods, however, are rather involved and appear to yield no additional information of value to the assessment of farm water supplies. The frequent and regular examinations carried out on public mains supplies permit a simplified procedure which would provide inadequate information from the few samples it is possible to examine for any single farm water supply. From these it is necessary to obtain detailed information, and it has not been found possible to depart from the orthodox procedure, lasting 3 or 4 days.

Samples for bacteriological examination should reach the laboratories as quickly as possible after being taken, preferably in less than 6 hours. Even when samples are stored at 3-5° C, quite appreciable bacterial changes take place [8], and storage at higher temperatures brings about even greater variation [9]. Misleading results may, therefore, be obtained if examination is delayed.

Significance of Bact. coli I

In this country, the generally accepted view is that Bact. coli I is essentially an index of recent excretal pollution, because it tends to die out within a matter of days in fresh water. This is undoubtedly true of public supplies where water is normally held in bulk for considerable periods. Most farm water supplies are not stored for any appreciable time, but are regularly fed from water-bearing strata seldom far removed from soil or soil washings; therefore, it may be the different conditions of storage that are responsible for the varied results obtained from surface supplies. There is a very pronounced seasonal variation [12], and it has been shown that maximum contamination occurs normally during late summer, and is at a minimum during late winter and early spring. Regular examination of individual farm supplies (Fig. 1) shows that, in addition to this effect, considerable day-to-day variations may occur, thus indicating that little importance should be attached to the results obtained from a single sample. A number of factors appear to be responsible, and the reasons are not yet fully known. Rainfall, temperature, and other climatic conditions undoubtedly have an effect, but it has also been shown that the survival of excretal organisms may be dependent upon soil type [13].

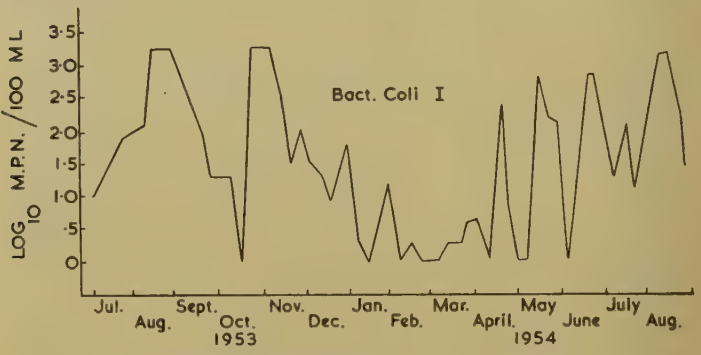

Fig. 1. Weekly variation of Bact. coli I in a spring supply

Water supplies from acid moorland normally show less contamination than those from limestone areas. Inoculation of representative soils showed that Bact. coli could persist in limestone soils for several weeks, but died out in a few days in acid peat soils. When chalk is added to acid soils, proliferation takes place and the organisms are able to persist for several months. This effect is shown in Fig. 2, but the published data make it clear that pH is not the only factor, and it is suggested that the presence and availability of nutrients is of considerable importance.

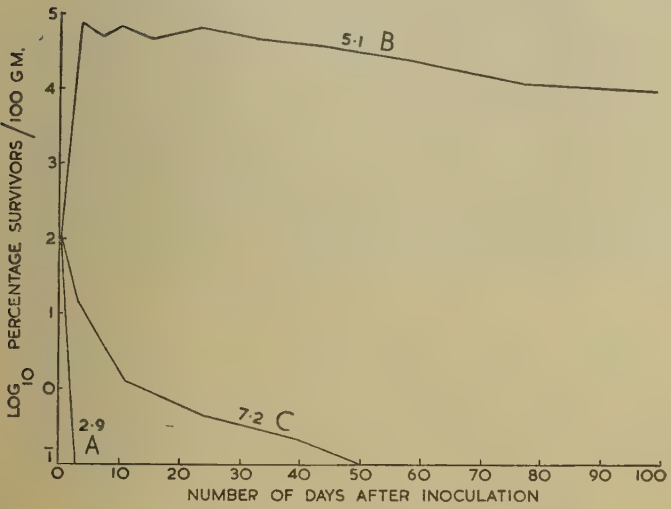

Fig. 2. Persistence of Bact. coli I in :

(a) an acid soil (pH 2.9)
(b) an acid soil + chalk (pH 5.1)
(c) a limestone soil (pH 7.2)

Field Data

Sources of farm water supplies are variable, and multiple factors may influence the bacterial flora, therefore complete and detailed field reports are essential. These often reveal potential contamination, and give information regarding the type of contamination which would not be apparent from the results of infrequent sampling [12]. The nature of the gathering ground and surroundings of the source give a guide as to possible sources of contamination, with the result that it is often possible to distinguish between supplies giving similar bacteriological results.

Assessment

Advisory Bacteriologists of the N.A.A.S. give guidance on the suitability of water supplies for dairy purposes. Normally, it is only possible to examine two or three samples from each supply, and classification solely on bacteriological grounds is not conclusive. Great importance is attached to the detailed field report which is prepared when the first sample is taken. A supply free from excretal organisms, and which is

supported by a satisfactory field report is obviously acceptable. Where the position and condition of drains, manure heaps and cattle watering places indicate that gross pollution is inevitable and cannot be removed, the supply is obviously unsuitable. Between these two extremes fall the majority of supplies; the first approach should be to bring about all reasonable improvements. When this has been done and the probability of human or gross animal pollution can be ruled out, some simple method of treatment should be possible to prevent contaminating organisms causing spread of disease or milk spoilage. Acceptance of bacteriologically unsatisfactory supplies, even though treatment may be prescribed, should be regarded only as a temporary measure until a more suitable supply can be made available.

Purification

Boiling will, of course, destroy the majority of bacteria and all the pathogens present in water, but it can only be done on a small scale. Chlorination by mechanical means under competent supervision is undoubtedly effective, but on a small scale, under farm conditions, inconsistent results are obtained as shown by Nichols [14]. Twelve chlorinated farm water supplies were examined at regular intervals and only three systems were regarded as operating satisfactorily. From these, 20 per cent of the samples were unsatisfactory.

A number of filters of different types are available and may be used on a small scale, but for quantities of more than a few gallons a day, difficulties of maintenance and cost of initial installation may preclude their general use. More recently, a water sterilizer using ultra-violet light has proved very effective, but this again may be costly and its efficiency may be reduced in the presence of suspended matter.

Because of these difficulties and the variation in the nature of the water to be treated it seems that treatment in the dairy with a suitable disinfectant is most likely to give reliable results. The use of an approved hypochlorite solution in udder washing and final rinsing water, to give strengths of available chlorine of 300 p.p.m. and 60 p.p.m. respectively, should ensure freedom from water contaminants in the water supply and be an adequate safeguard if waters of doubtful character must continue to be used.

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Reviews and Abstracts

Crop Husbandry

Sugar Beet

Establishment of this crop, and its effect on final yield have been subjects for several recent investigations. With two cold springs behind us, both leading to a slow and rather poor plant establishment, it is interesting to read about an investigation in Michigan, U.S.A., on 'The Effect of Cultural Practices on Emergence and Uniformity of Stand of Sugar Beets' by I. M. Wofford and S. T. Dexter (*Agron. Jour.*, 1955, **47,** II, 57). Although this report also describes experiments on the effects of various green-manuring practices, and different treatments to a preceding crop of lucerne, it is chiefly the study on types of seedbeds that is of interest in the U.K.

This seedbeds experiment compares the effects on the emergence of seedlings of the following types of seedbeds and sowing times :

1. *A loose, wet seedbed* prepared by using a clodbuster (presumably a scrubber) after spring ploughing, then sowing within an hour or so to avoid loss of moisture.
2. *A firm, wet seedbed* prepared by following the ploughing with two discings, two spring-tooth, and two tined harrowings, then sowing immediately.
3. *A firm, dry seedbed* prepared as for treatment 2, but with sowing delayed for three days.
4. *A loose, dry seedbed* prepared as for treatment 1; except that sowing was delayed for three days.

From loose wet, and firm wet seedbeds, sugar beet seedlings brairded earlier, with a more uniform stand, higher seedling emergence being recorded than from either of the dry seedbeds. Weed control was easiest on the loose, wet seedbed because of rapid seed emergence, and the beets on these plots looked more vigorous. Finally, the best effects were obtained when the sown rows on the loose, wet seedbeds were compacted with tractor wheels—probably a result similar to that given by the increasing practice in the U.K. of using small rollers behind drill coulters.

The 'Effects of Defoliation and Loss of Stand upon Yield of Sugar Beet' (*Ann. Appl. Bot.*, 1955, **43,** 63) is a report upon another aspect of sugar beet establishment, by F. G. W. Jones, R. A. Dunning, and K. P. Humphries of the School of Agriculture, Cambridge. In the field, it is often difficult to advise whether to plough-up and re-sow a thin or damaged beet stand, or whether to leave it, knowing that a reduced plant population and retarded crop will lessen yields to an unknown extent. Basing their findings on six replicated field trials extending over three years, these workers studied the effect of defoliation and reduced stand

produced artificially shortly after singling. They started with the optimum of approximately 30,000 plants per acre. Little loss of crop occurred until 50 per cent of the leaf area, or 50 per cent of the plant population had been destroyed, when the total root yield losses were 5 per cent and 10 per cent respectively. An interesting discovery was that the yield from re-sowing after complete removal of the plants was inferior to the yield from stands remaining but depleted by a half to two-thirds of their initial 30,000 plant population. Although the uniform and artificial removal of plants or leaves does not compare directly with the depredations of various important sugar beet pests, this paper provides some evidence on which to base estimates of real loss in the field. Naturally, a full yield can only be obtained from a full plant population, and compensation for pest damage cannot be expected from an initially thin plant population.

It is worth remembering, however, that there can only be a small proportion of growers who start the season with the magical number of 30,000 plants per acre. The British Sugar Corporation report that since the 1940-41 season, when the average 'national' beet crop exceeded 20,000 plants per acre at harvest, the average level has been consistently around 18,000 and 19,000 plants per acre. More work relating costs of production and net profit with crops at various populations is desirable, together with field trials such as those just discussed, using populations more nearly related to practice, as well as to the optimum plant population. The experiments of Jones *et al.* offer strong evidence that if one starts with a population only two-thirds of the optimum, there would not be much margin for the compensation factor to operate. Thus, inevitably one is returned to the first requirement of cultural practices to ensure an early, vigorous, uniform, and adequate stand of seedlings, of great importance to the new developments in mechanized 'down-the-row-thinning'.*

Oats, Peas and Beans

The thorny topic of production per acre of forage from oats, peas and beans, and from mixtures of these crops, has often been studied in the past, one investigation on grain mixtures in the south-west having recently been described briefly in *Agriculture* (August, 1954, p. 217). Since then, J. L. Henderson and R. O. Davies have reported on the yield and composition, at different growth stages, of mixed cereal—legume crops grown in Wales (*Emp. Jour. Exp. Agric.*, April, 1955, **23**, 131).

Oats, peas and beans, and a mixture of all three were sown as follows:

	cwt per ac.
Oats (S.84)	1½
Peas (Marathon Maple)	2
Spring beans	2

The three species were also sown at 2 cwt per acre in a 50-25-25 per cent mixture. The crops were cut and analysed at seven stages of growth,

*The theory and practice of 'down-the-row-thinning' is described by P. J. Jones in his article 'Labour-saving Methods of Row-crop Cultivation', *N.A.A.S. Quarterly Review*, No. 29, pp. 188-97.

from very early to full ripe. The authors take into account harvesting techniques and resultant losses on the farm. The three years' results show that oat-legume mixtures gave higher yields of dry matter than any of the species grown singly, but peas gave the greatest yield of crude protein. The authors state that in practice, the maximum yield of starch equivalent (estimated from dry matter and crude protein analyses) would be produced by cutting the mixture for silage between flowering and early grain formation.

Beans as well as peas and oats were included in the experimental crop mixture; the beans failed, however, to support the peas, and it was concluded that their contribution to the feeding value of the mixture could have been adequately provided by the latter.

Although peas on their own produced the maximum amount of crude protein per acre, either as silage or as grain, their variable yield in different seasons and the difficulty of harvesting them ripe in this wet part of the country, makes them a doubtful proposition when sown alone.

Dredge Corn

In contrast to this study of cereal-legume mixtures, the popular oat-barley mixture, when grown for the production of grain for feeding, has now been examined critically by the N.I.A.B. It has long been claimed that a mixture of two suitable cereals will outyield the constituents if grown separately; also there is greater safety in mixed crops should one constituent fail. During, and since the war, such mixtures have become increasingly popular, particularly in the west.

G. H. Daniel reports on twenty-six trials, mainly in the south-west and in Wales, in 'Dredge Corn Trials 1946-51' (*J. Nat. Inst. Agric. Bot.*, 1955, **7**, 309). Eagle oats and Camton barley grown alone were compared with $\frac{3}{4} : \frac{1}{4}$, $\frac{1}{2} : \frac{1}{2}$ and $\frac{1}{4} : \frac{3}{4}$ mixtures of the two. In twenty-two trials there was, on average, a gain in yield from the mixtures as shown below:

	Eagle	Mixtures			Camton
		$\frac{3}{4} : \frac{1}{4}$	$\frac{1}{2} : \frac{1}{2}$	$\frac{1}{4} : \frac{3}{4}$	
Yield percentage	100	108	109	107	100

In the other four trials the yield of oats grown alone was below 10 cwt per acre and could be regarded as a failure; the mixtures, however, were good enough to raise the yields to an economic level, and illustrate the value of dredge corn as an insurance against loss of crop.

The author comes to the conclusion that gain in yield alone does not justify cultivation of a mixed crop. On the smaller stock farms, however, it seems to be grown to great advantage. The varieties used in the trials are not those likely to be chosen today; Camton, for instance, is not easily obtained from the seed trade, but other varieties would probably serve the same purpose, provided they are matched for maturity. The trials make it clear that difference in straw length is immaterial.

Foliar Application of Nutrients

The use of spraying machines on farms is constantly increasing, and it is therefore not surprising that there is a growing interest in the application of sprayed fertilizer, either alone or mixed with some crop protection chemical.* Dr. Gillian Thorne summarizes our present knowledge on the subject very well in the Rothamsted Report for 1954: those seeking detailed information should read it. The general approach to the practical aspects of foliar application cannot be summed up better than by quoting the final paragraph of the review:

> In field experiments the effects of nutrient sprays are usually of the same order as for soil dressings, and rarely more than two or three times greater. Therefore, spray application does not result in a great saving of fertiliser, but may be preferable to soil application when: (1) soil conditions or a competitive crop make nutrients from soil dressings unavailable; (2) an accurately timed response to fertiliser is required, e.g. a change in the composition of a crop late in the season; (3) routine applications of insecticidal or herbicidal sprays, to which nutrients can be added, are made; (4) the growth of the crop prevents application of fertiliser to the soil but permits it to the leaves from a high-clearance sprayer or helicopter. If crops are to absorb nutrients applied in sprays through their leaves there must be sufficient leaf surface to retain the spray. This limits the usefulness of the application of nutrients in sprays to annual agricultural crops, because those most in need of fertiliser, i.e. young or starved crops, have only a small leaf area. Application of sprays is liable to be more expensive than traditional methods of fertiliser distribution, and therefore not economically justifiable, even when a saving in fertiliser results. Thus, although it is now well established that fertilisers applied in leaf sprays can be absorbed by crops and in some circumstances are more effective than fertilisers applied to the soil, the method is not likely to become very widespread. Apart from these practical considerations, nutrient absorption through leaves may prove very useful in theoretical studies on plant nutrition.

The stage of scientific study discussed in Dr. Thorne's review has already been surpassed: 'Foliar Application of Nitrogen on Grassland' by A. J. Low and E. R. Armitage (*Agriculture*, Nov. 1954, p. 368) and 'Foliar Application of Nitrogen to Winter Wheat' by H. W. Gardner (*Agriculture*, Sept. 1955, p. 267), are reports of recent field trials showing that foliar application of N to both grassland and winter wheat have no advantages in yield over an equivalent application of dry N fertilizer.

However, the latter paper shows that a June application of N, either dry as 'Nitro-Chalk', or as a urea spray, increases the percentage and total production of protein in the crop. This protein increase from very late N application also appears to occur in barley, but reports of these investigations have yet to be published. Perhaps the time will come when late foliar application of N fertilizer may be made to cereals intended for feeding, by virtue of the extra protein produced. Conventional ground application is obviously impracticable, but agricultural contractors owning aeroplanes might be able to perfect an economic airborne technique!

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*Further details of this method are given in a review article "The Foliar Application of Nutrients for the Treatment of Deficiencies in Crops" by T. H. Caldwell, *N.A.A.S. Quarterly Review No.* 30, pp. 241-52.

Eyespot-Resistant Wheat Varieties

Recent work by F. G. H. Lupton of the Cambridge Plant Breeding Institute and R. C. F. Macer of the School of Agriculture (now with the P.B.I.) has shown that Capelle Desprez is less affected by Eyespot (*Cercosporella herpotrichoides*) than the varieties Bersée, Squareheads' Master and Yeoman. In an article 'Winter Wheats resistant to Eyespot' (*Agriculture*, May 1955, p. 54) it is shown that Capelle was neither lodged nor was its yield more than very slightly reduced by an attack of eyespot, whereas other varieties suffered greatly. The mechanism of 'resistance' is not understood, and it is stressed that the growing of Capelle does not help clear the soil of the disease—indeed the reverse may be true. However, this information is of great value, for with the best will in the world it is often impossible to avoid sowing winter wheat on land carrying this disease today. Field evidence from N.A.A.S. trials and demonstration on commercial farms support these findings.

More recent work, yet to be published, suggests that the variety Minister may be similarly resistant to Eyespot.

C.V.D.
D.H.R.

Farm Management

American Views

The latest addition [1] to the ever-growing volume of textbooks on farm management in the U.S.A. has been prepared primarily for students in agricultural colleges and farm institutes, but may appeal to those who want to find out something about the American approach to the subject.

Advisers and students in this country will find this book useful, not so much for its descriptive and illustrative matter—which relate entirely to conditions in the United States—but because it demonstrates that farm management is much more than the analysis of farm accounts and their comparison with local averages or standards. The use of budgets, both for the whole farm and for particular enterprises, the management of individual enterprises, and the adjustment of production to prices, markets and risks, are all important facets of farm management. In these respects there is no doubt that farm management advisory work still has considerable leeway to make up before it is on a par with technical advice. As emphasized in this book, the essence of farm management is the study of the £ s. d. implications of all farm decisions and not merely the keeping of accounts.

Farm Management Workshop

A summary of the papers read at the International Workshop on Farm Management held in June 1953 at Bonn, Germany, has recently been published [2]. The meeting provided an opportunity of exchanging views on farm management developments in various European countries. Of especial interest is the insight that these papers give on the different

national approaches to the subject. The main papers from Western Germany include 'Advisory Groups and Farm Management', 'Farm Surveys and Farming Aims' (with a fully translated specimen of the standard Farm Survey form in use) and 'Bookkeeping, Statistics and Advisory Work'. Further papers deal with the Netherlands 'Management Advisory Service' and with 'Farm Management Work in England and Wales'.

Heifer-rearing Costs

Since April 1953, an investigation into the costs of rearing dairy heifers on selected north country farms has been conducted by the Department of Agricultural Economics, King's College, Newcastle-on-Tyne. Two reports on this study have now been published [3]. The average cost of 516 heifers calving during April/March, 1954/55 was £55 6s., although costs ranged from under £30 to more than £80 per heifer. This suggests that great economies in heifer rearing are possible on many farms. As with all enterprise cost investigations, it is difficult to isolate specific causes of high or low costs; however, one table in the second report indicates that savings of perhaps £8-£10 per heifer were possible by feeding milk substitutes in place of whole milk. There was no strong relationship between age at calving and cost per heifer. In 1954/55 the highest average costs per heifer occurred in the youngest calving group. In the previous year, average costs per heifer rose consistently with age at calving. The investigation was on too small a scale to establish which breed, if any, produced calving heifers at lowest cost. Within any one breed group there were numerous variations in management practices and farm situations which, in part, influenced heifer-rearing costs.

On the 52 farms included in the enquiry, 1.24 followers were kept per dairy cow in herd, and 5.07 acres of land (including acreage equivalent of purchased feeds etc.) were required per cow. There has been no analysis of these results to show the differences in costs between spring-born and autumn-born calves; nor is any comparison made between different methods of rearing weaned calves. There are wide differences in practice —some farmers turn spring-born calves out to grass when a few weeks old, whilst others keep similar calves indoors until they are twelve months old. Further study of the economic implications of these wide variations in practice is needed; these reports make a welcome start. Heifer-rearing costs are at present being collected on more than 350 farms throughout the country, and at the end of 1956 the first results of this investigation are expected. It is hoped that this will present the £ s. d. implications of many of the existing rearing practices and thereby provide valuable data for advisory work.

Sugar Beet

A study of sugar-beet growing on 65 farms in the West Midlands in 1953 demonstrates some important economies in the growing of this crop [4]. The crops (covering a total of 1,145 acres) ranged from 2-60 acres, the smaller acreages being chiefly on dairy farms and the larger acreages

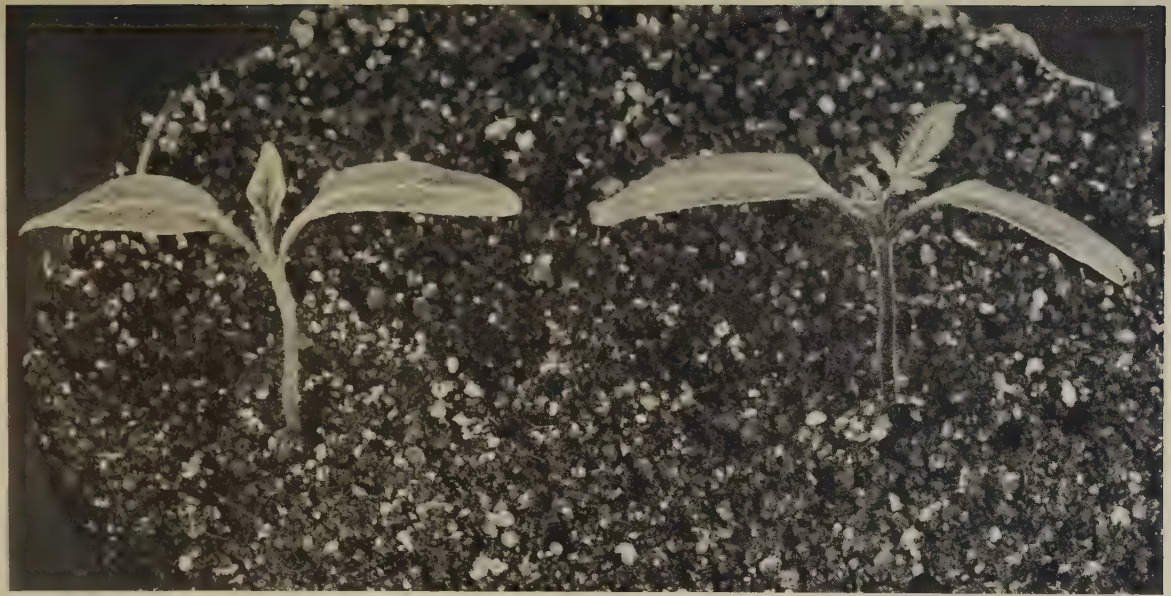
mainly on the bigger arable (or mixed arable) farms. Yields varied from six to over twenty tons per acre, and averaged 15.6 tons of clean beet, valued at £95 16s. 4d. Net costs ranged from under £40 to over £65 per acre, averaging £50 1s. 2d. Profit margins varied considerably; on six farms they exceeded £60 per acre. Costs per acre were fairly constant for crops of different acreages, only declining appreciably for those exceeding 30 acres. Receipts per acre (a combined effect of yield and sugar content) increased with acreage of crop. Therefore, the margin per acre increased with the crop acreage. High yields per acre (closely related to expenditure on manures) were important in obtaining a high margin per acre. Yields per acre were also related to the acreage of the crop, especially within the 10-60 acres range. Slightly narrower ridges resulted in increased yield. On larger acreages, mechanization reduced the cost of harvesting as well as the amount of manual labour required.

Grain Drying and Storage

With the return to free marketing of cereals, and the increase in the number of combine harvesters in use, the storage of grain on farms has become an important problem. An investigation covering 40 farms' drying and storage plants in the East Midlands in 1954 [5] showed that various systems of grain drying and storage have been successful on different farms. Farmers should study the costs and particulars of the different systems before making a large outlay. The costs of installing 30 ventilated bins or silos varied from £5 18s. per ton of grain stored, for a plant capable of storing 660 tons of grain, to £29 10s. per ton for a small plant capable of storing only 60 tons. Generally speaking, large installations of ventilated bin driers were more economical than small ones, because the cost of erecting the necessary buildings and fittings did not increase in proportion to their capacity. In this type of plant the emphasis was on storage, and less capital was tied up on purely drying machinery.

The average cost of drying, including depreciation of the building and interest on capital investment was approximately 30s. per ton; 10s. of which represented operating costs and the rest depreciation, interest, etc. The operating costs of in-sack or platform driers were rather high, compared with ventilated bins, but this was compensated by lower costs of installation. On the other hand, platform driers provided very limited storage facilities.

Capital costs of installing a continuous drier varied considerably, depending on the size of plant and the amount of storage required. The running costs for this type of drier varied from 6s. 4d. per ton to 16s. 5d. per ton and the overhead costs varied from 4s. 7d. to £2 14s. 1d. per ton. As the capital cost of the drier and its auxiliary equipment (i.e. the overhead costs) usually accounts for the major part of the cost of drying, it is important to match the size of the drier to its expected throughput to avoid unnecessarily high overhead costs. This point is reinforced by a graph which showed that the total drying and storage costs per ton in a new building were reduced by 40 per cent when the equipment was fully used, compared with similar equipment used to only one-half capacity.



Seedling Characters.

Left: Recessive type—green stem, potato leaf. *Right:* Dominant type—purple stem, cut leaf.

PLATE 1.

Floral Characters.

Left: Wild type selected for style reaching tip of anther cone.
Centre: Male sterile, enclosed style. Note the vase-shaped flower due to the petals being fused.
Right: Male sterile, projecting style.

PLATE II.

Farmer's Weekly

Intensive dairy farming on the perimeter of industry contending with atmospheric pollution and reduced sunlight.

PLATE III.

Rough grazing on the higher uplands.

Shallow soils and outcrop rocks add to the difficulties and costs of arable cropping.

PLATE IV.

As the seasonal price increases during 1954/55 were about £5 per ton for wheat, £7 per ton for barley and £8 per ton for oats, a considerable proportion of the total drying and storage costs may be offset by the higher prices in the late winter and spring. The seasonal variations in sales off farms have been influenced by these seasonal price changes and, although some errors have crept into the graphs illustrating these variations, there is evidence that sales off farms are now more evenly distributed throughout the season than during the years of controlled prices.

Economics of Milk Production

From 1934 until 1952 a yearly investigation of the costs of producing milk was undertaken by the Provincial Agricultural Economists attached to universities in England and Wales. A final report on the results for 1951/2 has recently been issued by the Milk Marketing Board[6]. This investigation was primarily concerned with production costs and, in chapter III of the report, the factors influencing production costs and margins are closely examined. To appreciate fully the conclusions to be drawn from the costs, due regard must be had to the conventions which necessarily have to be adopted in any cost accounting. In this connection, attention is drawn to the need for devising a satisfactory method of evaluating the feeding value of grazing. The immense differences in grazing from pasture to pasture, and from season to season, hinder a full and proper assessment of the economics of dairy nutrition.

The value of this investigation is not, however, confined to the information it provides on production costs. The appendix tables include information on the physical requirements not only for producing milk but also for growing feed crops. These requirements, e.g., of labour per cow or per acre, do not vary much from year to year, so that although the costs themselves may soon be a matter of history, the basic data can be brought to life again by pricing the inputs at current-day values. It is in farm planning and budgeting that the need for more detailed information on these lines becomes apparent.

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A.J.
L.N.

Storage of Flowers at Low Temperatures

Cold storage of hard fruits and, to a lesser extent, of vegetables in order to spread marketing of produce over a longer period, or to smooth out irregularities of supply, has become an established practice. In this country, the storage of flowers by similar means has been little investigated; trials made by growers have, on the whole, tended to create a prejudice against it because, in many instances, the flowers have proved unsatisfactory during or after marketing. Although the need for storing flowers will never be as great as for fruit, there are times when storage of up to a few weeks might help to avoid gluts or shortages, and the consequent violent fluctuations in price. Even the holding of flowers cut on Saturday until marketing on Monday or Tuesday—if practicable without loss of quality—could be valuable; while the exact timing of a flower crop for a particular holiday season, such as Easter or Christmas, would be less critical if successful storage methods were available.

Most of the attempts to store flowers in this country have consisted of holding them in water, at a temperature of 40-45° F for a week or ten days before packing and marketing in the normal way. Compared with freshly-cut produce, such flowers have usually been found to last for only a short time after selling, hence the prejudice against stored flowers. It is not uncommon to see boxes labelled, 'These flowers have *not* been cold stored'.

A knowledge of the reasons for flower deterioration is important. The contributory factors are listed below:

1. *Temperature is the chief factor determining respiration rate.* When a flower is separated from the parent, it can obtain no more food materials except for any small quantities that may be manufactured by leaves or other green parts on the flower stem. Because respiration continues, the life of the bloom must be limited by the reserves of food material available.
2. *Temperature is the principal factor governing the rate of flower development.* Normally, development of the flower continues after severance, and if this is not checked the bloom may soon pass beyond marketable condition.

3. *Humid conditions* favour rotting: various fungi, most of which grow mainly on the surface, may attack the blooms.
4. *Too dry conditions*, on the other hand, may lead to wilting or shrivelling.
5. The presence of mature flowers in an unventilated store may stimulate development and ageing of other blooms, for it is known that such flowers evolve traces of ethylene gas which has a strong stimulating effect upon respiration and other biochemical processes.
6. *Unfavourable temperature or light conditions* may induce fading or other colour changes in the flowers.

The American System

In recent years, pre-packaging and cool storage of a number of different commercial cut flowers have been the subject of extensive experiments in the United States, especially at Cornell University under the direction of the late Professor Kenneth Post. These trials were successful and have led to positive recommendations to growers. In America, the practice of keeping large quantities of flowers for periods of up to or exceeding four weeks, is rapidly increasing.

Work there has shown that the condition of the flowers at the time of cutting is important. Obviously, disease-free flowers are essential, since the high humidities necessary in store favour disease development. Flowers should preferably be cut in the afternoon or evening when carbohydrate concentration is at a maximum and the plants are well supplied with water. Keeping quality improves if the plants have been grown as cool as possible and under good light conditions.

Success of the American methods depends upon a combination of pre-packaging and dry cold storage. Flowers are best packaged immediately after cutting; it is claimed that no benefit is obtained either by temperature conditioning or by standing them in water beforehand. The latter merely reduces the time before the flowers reach the consumer, makes them untidy and messy to work with, and increases the risk of rotting in store. To avoid excessive moisture loss, speed is essential in packaging; the flowers are enclosed in transparent film wrapping in the form of a sleeve with the ends folded over and sealed with cellulose tape. Special grades of film are manufactured, which are moisture-proof but not wholly impervious to oxygen and carbon dioxide. The container should be of such a size as to keep the free air space to a minimum. The packages are then stored at 31°F, a temperature which must be fairly closely maintained. At lower temperatures, freezing injury may result; at appreciably higher temperatures, mould may develop. Flowers stored at 36°F may appear satisfactory when taken out but they deteriorate rapidly in water.

Flower Reactions

Carnations have been stored successfully by this method for up to five weeks, and chrysanthemums for four weeks. Roses and lilies may be stored for a fortnight at least, and tulips, narcissi and lily of the valley for up to three weeks, although the last usually have a slightly shorter life after store than fresh-cut blooms. Gardenias, cypripediums and cymbidiums also store well in dry packs at 31°F, but cattleyas are damaged at this low temperature and are best stored at 45-50°F. Gladioli have been found to be unsuitable for dry cold storage; the lower flowers on the spike shrivel subsequently, and at higher temperatures the upper buds open and the spike becomes worthless for market.

Post-storage Treatment

Conditioning of the flowers is necessary after storage at 31°F, because some water is lost from the plant tissues during storage. Cornell University recommends cutting the stems on removal from storage and placing them in water at 100-110°F in an air temperature of 40°F for 6-12 hours. The water, of course, soon cools, but it is found that this hardening treatment results in a rapid uptake of water which greatly improves the keeping quality. The flowers may then be packed and marketed in the same manner as fresh cut flowers.

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R.H.S.

Growth and Flowering of Fruit Trees

Rootstocks are widely used for top fruit, to influence the size of tree and the time and extent of cropping, but knowledge of underlying causes of the effects produced is very imperfect. A variety growing on its own roots expresses its individual characteristics as regards tree size and time of bearing, but when it is grafted on a rootstock, there is mutual interaction between the characteristics of the two component parts. Research workers in different parts of the world have not agreed on which is the dominant partner; some experiments have shown dominance by the rootstock and others dominance by the scion.

A series of experiments was started at East Malling some years ago to study the inter-relationship of rootstock and scion, and two publications on this work, restricted to very young trees in their establishment phase, have recently appeared. The first of these is about tree size as determined by weight and the second discusses the beginning of flowering.

Vyvyan [1] deals with two problems in his paper:

1. The extent to which growth rate and resultant size of young trees are determined by the growth rates of the component varieties, e.g., will the sum of the weights of the composite trees A/B and B/A tend to be the same as that of trees of varieties A and B growing on their own roots ?
2. Will the rootstock or the scion be the dominant partner, e.g., will A/B most resemble A/A or B/B ?

Since it is necessary to use each variety both as scion and as rootstock, it is essential that all the varieties are easily rooted. It is convenient, therefore, to use rootstocks, and Vyvyan used the apple rootstocks M.IX, M.IV and M.XII, combining them in all nine possible ways. The trees were weighed at planting, and at intervals during the following three seasons certain of the trees were dug up and weighed.

Growth Rate

Increments in size of young trees should probably not be considered in terms of the actual growth rate (W_2-W_1), for growth during the season is likely to be related to the size of the tree at the beginning of the season, and the relative growth rate $\left(\frac{W_2}{W_1}\right)$ is therefore preferred. When the mean relative growth rates of trees with reciprocal grafts (Unlike unions) between two varieties, e.g., IX/XII and XII/IX, are compared with the mean rates of those composed entirely of each of the varieties (Like unions), e.g., IX/IX and XII/XII, it is found that the mean growth rates are almost the same, although for Unlike union trees they are consistently slightly lower than for trees with Like unions. This is not surprising when one considers how much varieties differ in their structure and growth rhythms; the mutual adjustments that are needed may well result in a slight reduction of growth. The close agreement between the growth

rates indicates that the growth rate of the composite tree is mainly a balance between the growth rates of the component varieties during the first two years of its life.

Rootstock Dominance

Examination of the relative influence of rootstock and scion showed conclusively that the rootstock had the far greater influence in determining tree weight, and composite trees, e.g., IX/IV, usually resembled those of the rootstock variety, e.g., IV/IV, more than the scion variety, e.g., IX/IX. At the beginning of the experiment the trees on M.IX were heavier than those on M.IV or M.XII, but at the end they were much lighter. This experiment was concerned only with the first three years of growth: the rootstock year—towards the end of which the rootstock was budded—and the first two years of scion growth. Thus, until the third year the rootstock comprised the greater part of the tree. Size differences in older trees might be the result of differences established during these early years, or might be the result of subsequent differences in relative rates of growth.

Maggs [2] makes use of a similar set of trees composed of the sixteen possible combinations of four apple rootstock varieties, M.IX, M.IV, M.II and M.XVI, worked together in pairs. He also included unworked trees of each of these rootstocks to estimate any effect of budding.

Before a young apple tree, raised by budding or grafting from an existing variety, begins to flower, it repeats the pattern of growth already established (new shoots, secondary thickening and new roots) but when it begins to crop there is a change in its metabolism leading to the production of flowers, fruits and seeds. The process appears to be different from that operating in an annual or biennial plant, which passes through a more or less distinct 'juvenile' or seedling stage before reaching the mature flowering stage; the apple tree is in the *mature* condition and the *seedling* stage of non-flowering has already been passed through before the tree was propagated.

Blossom Studies

The experimental trees were planted in 1950, and budded in the same year. In 1952 any blossoms produced were removed, but in 1953 certain of the trees were allowed to blossom and fruit, so that the effect of fruiting on growth could be observed. In this experiment, as in Vyvyan's, the young trees were dug up and weighed at intervals, and by 1954 there were insufficient trees left for the blossoming studies to be continued. The results show that there is a general similarity in the behaviour of a variety as a scion and as a rootstock; thus with M.IX in either role, just over 60 per cent of the trees produced blossom in 1953, whereas with M.XVI, less than 10 per cent produced blossom. A similar effect was also shown in 1954, the order for decreasing flower production being M.IX, II, IV, XVI. More of the budded trees blossomed than the unworked trees.

There was also a close agreement between the proportion of trees flowering and the mean number of inflorescences per tree. Careful examination of this interesting point showed that there is a definite relationship between these two variables, suggesting that the cause initiating flowering also operates in the subsequent production of flowers. The curvature of the graph of the percentage of trees flowering in each treatment, and the mean log numbers of trusses per tree, implies that the rate of increase in number of inflorescences per tree, is greater than the rate of increase in the number of trees coming into flower. It seems, therefore, that the inception of the flowering condition requires more stringent conditions than does the production of flowers once this condition has been reached. Thus, if flowering in the apple is controlled by a critical value of a casual factor in the individual bud, when any one bud has nearly attained that value, it is likely that other buds will have done so too, the actual numbers being determined by the treatment. This mechanism does not, however, indicate why one tree may be blossoming heavily, while its similarly treated neighbour is devoid of blossom. *Provided* sufficient trees are used, this relationship may be of practical use in experiments affecting flower production, where instead of laboriously counting the number of trusses per tree, the result may be recorded by counting the number of trees flowering in each treatment.

Part of this investigation concerned the influence of the flower trusses borne in one year on the number borne in the following year. Deblossoming of heavily blossoming trees usually tended to reduce the tendency to a biennial rhythm; this was observed with M.IX, M.IX/IX, M.IV/M.IX. However, with vigorous trees that flowered lightly, the removal of the few blossom trusses tended to permit continued vigorous growth and sparse flowering in the following year.

Flower trusses in 1953 were classified according to their position, and the results showed that M.II, both as rootstock and as scion, produced more axillary than terminal trusses, with the reverse true for M.IV; M.IX was intermediate. There were insufficient flower trusses on M.XVI to reach any conclusion.

The relationship between rootstock and scion, and their relative influence on trees more representative of established and cropping trees is the subject of a forthcoming paper by Beakbane and Rogers to be reviewed later.

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H.B.S.M.

Pasture Management and Livestock Production

To obtain the most efficient utilization of grassland, it is important to know what effect different managements may have on the productivity of livestock. Accurate information on this vital topic is inadequate, and therefore several recent papers dealing with the influence of grassland management on livestock productivity are particularly interesting.

Grazing Systems and their Effect on Milk Production

The influence that different grazing managements may have on milk production in New Zealand has been described by Hancock and McMeekan[1]. The managements studied were frequent rotational grazing of stock moved into a fresh paddock every day, and continuous grazing. In the latter treatment cows were kept on a day and night paddock system, and only rarely had access to fresh pasture. The total area allocated per cow was constant and, apart from the grazing treatment, all other managements were the same. The livestock grazing fresh pasture daily produced almost 20 per cent more milk than the animals which grazed the same area continuously. In addition, the more controlled grazing enabled a greater conservation of hay and silage. Under continuous grazing, the pastures could not be rested to the same extent and most of the surplus spring herbage was wasted.

McMeekan and Hancock [2] have also compared two systems of controlled grazing—strip and rotational. The stocking rate per acre was the same in both; dairy cows on the rotational system remained in one paddock until a similar group of animals had completely strip grazed an identical area (average time for grazing a paddock was 4.2 days). No substantial difference in milk production was detected between the two treatments. It is interesting to compare this result with that of Holmes *et al.* [3] in Scotland. In a similar experiment they found that, compared with rotational grazing, strip grazing gave a considerable increase in production per acre. (The rotational grazing averaged 3-4 days per paddock.) The major difference between the two experiments lay in the stocking rates. McMeekan and Hancock had the same overall stocking rate on both treatments, while Holmes *et al.* allocated a larger area per cow on the rotational system than on the strip grazing (ratio 4 : 3). The milk production per cow was not affected by the grazing treatment in either experiment. Since Holmes *et al.* had a higher stocking rate per acre on the strip grazed treatment, the yield per acre was higher from this system than from the rotational grazing.

Calf Reactions

McMeekan [4] describes a New Zealand experiment which compared different systems of rearing spring-born calves on pasture. One group was reared in a calf paddock from birth to weaning; after weaning these calves were transferred to a dry stock paddock containing ample feed. The other group of calves was moved ahead of strip-grazed cows from

2 weeks of age until weaning; they then continued rotation grazing and never spent more than 3 days in one paddock. A considerable number of comparable calves were reared under both systems; the average weight of the set-stocked calves at 8 months of age being 291 lb, and at 20 months, 586 lb. Corresponding figures for the rotationally-grazed calves were 396 and 744 lb respectively.

In the north of England, Preston [5] compared pasture-reared calves with those reared indoors. During 1953, calves were reared outside by strip grazing over pasture not previously grazed by cattle, and by the autumn they were the same weight as comparable calves reared indoors. Both groups were then housed during the winter and turned out to grass during the following spring, during which period the outdoor calves did better, and by late spring weighed 100 lb more per calf than those reared indoors. The experiment was repeated in 1954, outdoor calves being rotated on six permanent paddocks. In this second experiment, results were reversed; the indoor-reared calves did better than the grass-reared, possibly because of the very wet summer. During the wet weather, the grazing of the calves was adversely affected, they did not thrive so well and were probably more susceptible to parasitic infestation. High worm-egg counts from the grass-fed calves towards the end of the 1954 summer confirmed this supposition.

Sheep and Lambs

Live weight production of lambs under set stocking or rotational grazing (moving flock about every other day), was studied by Lambourne [6]. Sheep were kept at three levels of stock on both systems, i.e., 4, 6 or 8 ewes and their lambs per acre. At the two lower stocking rates, the set-stocked lambs tended to do better, but at the higher rate, the rotationally-grazed sheep and lambs produced the best results. Apart from more efficient utilization of grass, rotational grazing may have beneficial effects by controlling worm populations in sheep. Spedding [7] showed that even a sub-clinical infestation of worms may adversely affect the live-weight gains of lambs, and that by controlled rotational grazing it is possible to rear worm-free lambs with consequent gains in live weight production. Two groups of lambs were reared; one group was moved at least every two days over fresh pasture uncontaminated by sheep. The second group was folded over land previously infected by ewes. The lambs rotationally grazed on worm-free pasture gave negative egg counts for the important nematode species, while the number of eggs in the lambs on infected grass rose sharply until checked by dosing with phenothiazine. From May to July, the live weight increase of the worm-free lambs was 15 per cent higher than the infected lambs.

Mixed versus Single Stocking

The influence of mixed stocking (cattle and sheep) or single stocking (sheep alone) on live weight production per acre, was studied by Walker [8]. The mixed stocking also included two different ratios of sheep : cattle.

Live weight production per acre per annum was the same on all methods of stocking investigated. However, there was some deterioration of the swards which were stocked solely with sheep, and it is likely that this would eventually have an adverse effect on productivity.

Pigs Penned or Folded?

Experiments on the use and management of pasture for fattening pigs have been described by Eyles and Alder [9]. Lenient folding over either a predominantly grass sward or a sward dominated by clover was compared with the fattening of pigs in pens. In addition, two levels of feeding were compared on the folded pigs; one set of pigs received the same meal used for the penned group but at a reduced rate of feeding. The other method was to feed a lower protein ration at the same rate as that used in feeding the penned pigs. During the period of 50-120 lb live weight per pig, lenient folding plus a reduced feeding rate saved 34 per cent of the meal. Folding plus a low protein ration only, saved 9 per cent of the meal but there was a greater saving of protein concentrate (56 per cent). It was considered that pigs on pasture should receive a medium protein meal from 50-120 lb live weight, and that the meal should be fed at a reduced rate using a modified 'Lehmann' system. From 120-190 lb live weight a low protein meal and grazing would probably save a reasonable quantity of meal.

In another experiment, free grazing was compared with close folding on both grass and lucerne. Better live weight gains were obtained by free grazing because the pigs were able to select the more nutritious material; in addition damage to the swards (and particularly to the legume constituents) was less. Free grazing on lucerne saved 34 per cent of meal consumption, and on grass 25 per cent. For the greatest saving of meal during the period from weaning to slaughter, it was concluded that pigs should have free range at a medium stocking rate on a young, dominantly leguminous sward. By rotating the pigs on a number of paddocks the pastures would be rested and a better control of pig parasites obtained.

Nitrogen

The influence on milk production of differential applications of nitrogen to grassland was reported by Holmes [10]. Dairy cattle were rotationally grazed on pasture which received two different levels of nitrogen. There were considerable responses in milk yield varying from an additional 163 gal per acre in 1951, when the rate of nitrogen was raised from 63-166 lb per acre, to an additional 168 gal per acre in 1953, when the dressing was increased from 20-216 lb nitrogen per acre. Prendergast and Brady [11] also showed that the output of meat could be considerably improved by nitrogen. Bullocks and sheep were rotated around ryegrass swards which received either 0 or 7 cwt of 'Nitro-Chalk' per acre per annum. An additional 135-150 lb live weight per acre resulted from the 7 cwt dressing.

Seeds Mixtures

Livestock output from different seeds mixtures was studied by Hunt and Thompson [12]. A commercial seeds mixture based on Irish ryegrass, American cocksfoot and Scotch timothy was compared with an Aberystwyth seeds mixture based on S.23, S.143 and S.48. At the end of four years, the Aberystwyth sward had produced an extra 92 lb of live weight and 289 more grazing days than the commercial strains. There was a marked difference in persistency between the two ryegrass types. At the end of four years, the percentage of Aberystwyth ryegrass was 42 per cent and the commercial ryegrass 28 per cent; despite this, the commercial swards still produced the most herbage in the last two seasons. The biggest difference in productivity was in the seasonal distribution; the commercial sward was 2-4 weeks earlier than the Aberystwyth, while the latter continued to grow rather later in the autumn.

Prendergast and Brady [11] also compared production from two seeds mixtures based on either Aberystwyth strains (S.23, S.101, S.143 and S.48) or commercial strains (Irish perennial ryegrass, Danish cocksfoot and American timothy). They, too, found little difference in total livestock production from the two sward types. In a later paper [13], Prendergast and Brady showed that the distribution of seasonal production was similar to that found by Hunt and Thomson [12]. This seasonal variation reflected the difference between S.23 and commercial ryegrass, which had become the dominant grasses in their respective swards. From the differences in seasonal productivity of the above swards, it appears that they are complementary rather than antagonistic, and that together they would ensure a more even distribution of production throughout the year.

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H.K.B.

Machinery

Grain Drying, Storage and Handling in European Countries

This booklet, which is obtainable on loan from the Libraries of the Ministry, is a Report on the Training Course sponsored by the European Productivity Agency of the Organization for European Economic Co-operation (under arrangement with the United States Foreign Operations Administration), and held in England in September-October 1953. It includes the 16 papers read about particular aspects of grain drying and storage problems, together with the gist of the information that arose from the discussions that followed.

The papers cover various methods of harvesting grain, including collection or disposal of the straw; grain handling, reception, cleaning, drying, conveying and storage; methods of measuring grain moisture content; and methods of preventing or minimizing damage to grain during harvesting by combine, or during storage through the action of insect pests and rodents. Problems of marketing were also considered, and papers covered farmer-co-operation in grain drying and storage schemes, the requirements of millers and maltsters, and various economic and financial aspects of the problem.

Some of the papers contain useful technical information not hitherto easily available. For example, the paper by Professor J. J. I. SPRENGER of Holland includes some of the most important results of studies at the Dutch Laboratory for Drying Technique. Equilibrium curves for grain moisture content and air relative humidity for wheat at various temperatures are presented. A table showing maximum drying temperatures for milling wheat, malting barley and seed corn at various moisture contents gives figures slightly lower than those accepted as safe in Britain; but the observation is made that they give a margin of safety of 10°C, and this is probably necessary in Holland on account of references elsewhere to the use of rotary drum driers which employ initial air temperatures of 140°C.

E. N. GREER in his paper on *Risks in the Storage of Grain Crops* adduced data showing that wheat and barley at 14 per cent m.c. can be heated for half an hour at 60°C (140°F) without any damage to germination, while ability to germinate was completely destroyed by

heating for half an hour at 73°C (164°F). For grain at higher moisture contents, these critical temperatures are much lower, the 'no damage' point being 48°C (118°F) at 30 per cent moisture content. In the paper by F. S. MITCHELL on the subject of damage to wheat during combine harvesting, it is shown that germination of corn harvested in a damp condition may be impaired at harvest by a high drum speed or narrow concave setting, even if the grain is immediately dried. Optimum moisture content at combining from the viewpoint of minimum grain damage is 16-18 per cent m.c. Below this level, more grains may be cracked.

Liquid Manure Handling. *Second Report of West Scotland College of Agriculture on Investigations by Members of the College Staff.*

This report deals with (*a*) the suitability of various types of pumps for handling liquid manure, and (*b*) the pumping of liquid manure over the dung heap.

Tests were made with three pumps, as follows:

(1) A 2-in., self-priming, centrifugal 'non-choking' type, costing £107 complete with a 5 b.h.p. petrol engine. Rated output was 165 gal per minute against 25 ft total head.

(2) A 2-in. helical screw type, costing £128 complete with a 3 b.h.p. petrol engine, and delivering (rated) 54 g.p.m. against 50 ft total head.

(3) A 1½-in., self-priming, diaphragm pump, costing £60 complete with a 1¼ b.h.p. petrol engine, and delivering 17 g.p.m.

When pumping clear liquid, all pumps were satisfactory, and outputs corresponded well with rated capacities. When pumping slurry, there was a great deal of wasted time with the centrifugal pump, which had to be dismantled in order to clear the clack valves. This particular pump proved quite incapable of handling a thick sludge, owing to choking of the valves.

The helical screw type dealt satisfactorily with a light slurry, but handled a thick sludge with difficulty, the number of stops caused by blockages being considerable. The diaphragm type was able to handle both slurry and sludge, though it had a number of stops caused by choked valves.

The general conclusion was reached that it is important to ensure a reasonably clear liquid, and that if this is done, the pumps with high outputs could be efficiently employed. Unfortunately this is not at all easy to achieve, and a comparison with methods that cause the sludge to be moved either by compressed air or by a vacuum would have been of interest.

The study of spreading liquid manure over dung heaps showed that in the West of Scotland, where heaps are not covered, there is likely to be little advantage in the practice. In order to achieve satisfactory results it would be necessary to roof the dungstead, at a cost of £300-400, and also to have plenty of straw. In some circumstances, however, the cost of roofing could be justified.

C.C.

Estimation of Losses in Farm Crops caused by Fungal Diseases

In 1949, W. C. Moore [1] pointed out that although there existed much valuable qualitative information on the distribution and importance of plant diseases in Britain, there were very few precise estimates of the losses caused by specified pathogens. Since then some progress has been made in remedying this deficiency; different methods have been successfully used and reasonably accurate estimates of crop losses obtained. More well-planned, wide-scale surveys are obviously needed for a proper appreciation of the relative importance of each disease, and a knowledge of the areas where control measures are necessary.

Potato Blight

Considerable attention has been given to Potato Blight (*Phytophthora infestans*). With the help of a simple key, Large [2] has shown how a series of estimates of the amount of foliage destroyed by blight may be plotted to give a curve for the progress of the disease in any crop. The point on this curve at which 75 per cent of the foliage is destroyed is taken to indicate the time at which tuber growth ceases. By studying such curves in conjunction with the data from bulking trials, it is possible to estimate the reduction in yield caused by blight. Large pointed out that it is necessary to check the estimates obtained in this way with results from trials in which the progress of the disease is retarded by protective spraying. This has been done in two different parts of England. In the Goole district of Yorkshire, Beaumont, Bant and Storey [3] recorded yields from sprayed and unsprayed Majestic plots for the seasons 1947-1951. Yield gains from protective spraying agreed closely with the losses of crop due to blight, estimated from the progress curves of the disease on the foliage. In three years, 1947, 1949 and 1951, blight did not appear until the end of the growing season and losses were nil. In 1948, the loss due to blight was 9 per cent and in 1950 it was 13 per cent. Similar experiments have been reported by Large, Taylor, Storey and Yule [4] for the years 1948-53, in the potato-growing area around the Wash. Here again there was close agreement between the estimated losses calculated from the progress curves, and the actual gains due to protective spraying. With the variety King Edward the losses due to blight were 1948—32 per cent, 1949—nil, 1950—27 per cent, 1951—2 per cent, 1952—nil, 1953—32 per cent and with Majestics in 1953—18 per cent. The variation in the results from these two areas emphasizes the importance of this work as a basis for realistic advice on protective spraying in different parts of the country.

Scab

A second type of trouble, in which the effect of a disease is to lower quality rather than quantity, was tackled in the Survey of Common Scab of Potato in 1952 and 1953 [5]. Area Officers of the Potato Division, classified the surface area covered by scab as under $\frac{1}{8}$, $\frac{1}{8}$ - $\frac{1}{4}$, and over $\frac{1}{4}$, in ware samples from about 2,500 crops each year. In 1953, which was a wet year, only about 2 per cent of the ware crop comprised tubers with $\frac{1}{4}$ or more of the surface covered by scab, but in 1952, when June and July were dry, this figure was almost exactly doubled. About 16 per cent of the 1952 crops in England and Wales had 3 or more lb per cwt of the tubers $\frac{1}{4}$-covered by scab, and an additional 2 per cent of the crops had over half the tubers $\frac{1}{8}$-covered. In Scotland only 5.4 per cent of the crops had 3 or more lb per cwt of tubers $\frac{1}{4}$-covered by scab, and this included the few crops with over half the tubers $\frac{1}{8}$-covered. Scab occurred in all parts of Britain, but the incidence was greatest in the North and East Ridings of Yorkshire, east Lincolnshire, Nottinghamshire, Warwickshire, Staffordshire, Shropshire and the Northumberland-Durham border area. In both seasons it was particularly severe on light sandy, gravelly and limestone soils, and in fields recently ploughed from turf.

Choke

Surveys were carried out in 1951-53 [6, 7] in order to obtain accurate information on the economic significance of Choke Disease (*Epichloe typhina*) in cocksfoot, which was causing some alarm in the seed trade. Seed crop inspectors examined all crops of the Aberystwyth strains S.26, S.37 and S.143 and assessed the amount of choke as 'absent'; 'occasional' (seen in a few quadrats); 'frequent' (up to 10 per cent in most quadrats); 'severe' (over 10 per cent in most quadrats). In addition, about 10 per cent of these crops were surveyed intensively by the plant pathologists who counted the fertile and choked heads in ten 1-ft length samples per field. The two methods of survey gave similar results; the field inspectors' ratings of 'occasional', 'frequent' and 'severe' approximating roughly to 0.1-10 per cent, 11-40 per cent and over 41 per cent respectively of the plant pathologists' counts. Over the three years 2,029 crops were examined by the inspectors and 226 by the plant pathologists. The total loss due to choke amounted to only 3 per cent. There were important differences in the losses of crops of different ages. In the few crops in their fifth to seventh harvest the average loss was 21 per cent, in fourth-year crops 9 per cent, in third-year crops 7 per cent, in second-year crops 1-2 per cent, and in the first harvest year losses were negligible. There were no important variations in the amount of disease in the three different strains of cocksfoot. The survey clearly showed that serious losses were mainly confined to crops which had become unproductive for other reasons, and that the fears of the trade about this disease were largely unfounded.

Mildew in Cereals

Although cereal mildew is one of our commonest diseases and is suspected of causing serious reductions in yield—particularly when a mild winter is followed by a dry spring—no precise information on this subject was available until recently. Last [8] in 1954 was able to control mildew in plots of Plumage Archer barley by spraying with lime sulphur, and comparing their yields with those from unsprayed plots. Lime sulphur spraying did not influence the yields of the mildew-resistant variety Haisa II, and it may be safely said that the higher yields of the sprayed Plumage Archer plots is a measure of the loss due to mildew. He found that in plots sown on March 22, mildew caused a 13 per cent reduction in yield or 5 cwt per acre, and in plots sown on April 5, a 22 per cent reduction or 8 cwt per acre. These figures were so striking that similar trials are now being carried out at a number of centres to assess over a period of several years mildew losses on a range of cereal varieties.

Yellow Rust

A similar state of ignorance prevails with another prevalent cereal foliage disease, Yellow Rust, caused by *Puccinia glumarum*. However, at thirteen centres over the period 1945-7, Batts and Elliott [9] have obtained an estimate of the loss that this disease may cause in a susceptible variety Wilma, by comparing its yields with those of a resistant variety, Juliana. When little or no mildew was present, these varieties had about the same average yield, but in crops where rust attacks started before mid-June, the yield of Wilma fell from 10-30 per cent below that of Juliana, the average depression being 22 per cent. These results show the need to study the 'rust resistance' of new varieties before they acquire wide popularity.

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H.E.C.

Poultry Husbandry

Table Poultry Production

In this country table poultry production is rapidly assuming the proportions of a major agricultural industry. Improved methods of production are therefore of great importance, and a number of interesting papers on the subject have recently been published. A contribution on the 'Differential Growth of Organs and Edible Meat in the Domestic Fowl' by E. S. Hafez (*Poultry Sci.*, 1955, **34,** 745-53) draws attention to changes relative to viscera and carcass weights during growth over 27 months. Hafez shows how most body organs show maximum relative growth over the the first five months of age, but little change from the eighth month onward. This is of some importance in considering normal strains of birds intended for broilers (10-12 weeks) or roasters (20 weeks). The writer found that with his strain, the yield of edible meat (i.e., unboned dressed carcass) was 66 per cent at 5 months and 63 per cent at 12 months. At 12 weeks, 60 per cent is barely achieved. The author believes that the percentage of dressed carcass is reversely related to egg-laying capacity.

Early growth is of great importance to the broiler producer, but a paper on the 'Percentage Size of Chick at Hatching and its Relationship to Growth and Mortality' by J. B. O'Neil (*ibid.*, **34,** 761-4) supports the contention that the body weights of chicks weighing at day-old less than 65 per cent of the setting weight of the egg, are as variable at 6 weeks as those with a higher percentage. It seems that the table poultry producer does not gain any advantage from large chicks—so far as the final weight is concerned. But O'Neil does produce evidence to show that those chicks representing a smaller percentage of the setting weight of the egg tend to be females, and that among such chicks mortality is heavier and earlier. At the same time it has been contended by several workers that before 8 weeks old mortality rate does not differ between the sexes.

On another aspect of table poultry production, viz. 'Factors Affecting the Efficiency of Food Conversion in Poultry' by W. Bolton (*Proc. Nut. Soc.*, 1955, **14,** 23-32), it is shown that the efficiency of conversion of food to meat is highest with males hatched from eggs laid early in the year. The author also points out that because the net efficiency of food conversion is constant, the table chickens' food should not be rationed and should be highly digestible. The author says that this is frequently forgotten when assessing the merits of strains of chicken as converters of food to flesh, and he stresses the need to ignore gross food intake but to place emphasis on feeding rations of similar make-up, and particularly having similar relative digestibilities of the different constituents.

Use of Arsenical Substances

In recent years, arsenical compounds have been used to a limited extent for improving the growth of broiler chickens. Their use is as yet far less

common than the use of antibiotics, but an increasing number of reports indicate that they may become a regular addition in American broiler rations. 'Arsonic Acid in Commercial Broiler Rations' by J. L. Milligan, H. L. Wilke, J. E. Marr and R. M. Bethke (*Poultry Sci.*, 1955, **34**, 794-9) gives an account of the results of experiments in which 0.005 per cent arsonic acid was added to broiler rations containing antibiotics. In all but a few of the trials the supplement led to an improvement in the final weights when compared with the controls. Carcass quality was also improved, but there was no real improvement of food conversion. In some of the birds occasional unsteadiness in gait was observed and a non-toxic level of arsenic was noted in the tissues of the birds treated.

Arsenical compounds have also been fed to turkeys. The results are discussed in a paper on the 'Effects of Arsonic Acid Derivatives and a High Level of Aureomycin on the performance of Turkeys to 24 Weeks of Age' by W. F. Pepper and S. J. Slinger (*Poultry Sci.*, ibid., 928-34). The birds received additions of 3-nitro, 4 hydroxyphenylarsonic acid, arsanilic acid and a high level of aureomycin in diets already containing 4g of penicillin per ton. All three experimental diets increased growth and feed efficiency during the first four weeks but, by eight weeks, only the two groups containing the 3-nitro, 4 hydroxyphenylarsonic acid and the high level aureomycin exceeded the weight of the controls, and by twenty-four weeks none showed a significant improvement over the controls. All three treatments appeared justified, however, because of improved food conversion. These results relate to birds reared in sun parlours. With turkeys reared on deep litter, the 3-nitro, 4 hydroxyphenylarsonic acid and aureomycin led to increased weight mainly in the males; the arsanilic acid had no effect. Birds on deep litter were heavier and had a better food conversion rate than those in the sun parlours, probably because of increased consumption of the experimental diets. An increase in perosis was noted and it would seem that the requirement of those factor(s) necessary to prevent this disorder is increased by using the drugs.

Further information on the effect of arsenical compounds is contained in a paper on the 'Effect of Long-Time Feeding of Certain Arsonic Acids to Chickens' by D. A. Libby, R. J. Evans, S. L. Bandemer and P. J. Schaible (*Poultry Sci.*, ibid., 972-80). Various combinations of arsonic acids with and without penicillin were employed. Both the arsenical compounds and the antibiotic stimulated early growth and improved the food conversion rate. But the effects of the arsenical compounds and the penicillin were not additive. Up to the ten weeks' stage, birds which were reared on the floor were heavier than battery-reared birds, but the females gave a greater response than males to the arsenicals. Penicillin had the effect of increasing the arsenic in the tissues, and it is suggested that the response generally experienced with antibiotic feeding is associated with improved absorption and utilization of certain minerals. Some of the experimental birds were reared on grass range and showed no growth response to the addition of arsenic.

Mature birds were housed over a year and fed with and without arsenical compounds. The two compounds employed were arsanilic acid and the dodecylamine salt of p-chlor phenylarsonic acid. Egg production of the adult birds fed with either of the arsenical compounds was significantly higher than the controls, but the arsanilic acid was the more successful. Hatchability was not affected.

Feeding of both the arsenic compounds resulted in deposition of small amounts of arsenic in the eggs; this was not increased further because of the presence of penicillin in the diets. The amount of arsenic in the edible flesh, liver and eggs is stated to be less than that occurring naturally in certain foodstuffs.

In the limited controlled experiments in this country, the results of the inclusion of 3-nitro, 4 hydroxyphenylarsonic acid have been variable—as often negative as positive. Deposition of arsenic in tissues such as the liver has exceeded the accepted limits for human foods.

Sex-Ratio at Hatching

A letter on 'Variations in Sex Ratio' in day old chicks by A. HANBURY-SPARROW (*Lancet*, July 1954, 196) makes the suggestion that the sex ratio is not constant, but may be influenced by conditions prior to mating. It is further suggested that favourable conditions result in more females. The writer cites occasions in the spring of 1954 when, although fertility and hatching rates were normal, the number of cockerel chicks significantly exceeded the females with a cross that was not particularly fecund and which was laying below average at the time. With a more fecund cross, laying substantially above the level of the former, the sex ratio was approximately equal. The writer also points out that the first cross, although persistently poor in fertility and hatchability, produced good, easily-reared chicks. The author suggests that the reason for the excess of cockerels is not due to greater numbers of pullets failing to hatch out, but that a real excess of males existed and may be attributed to a physical weakness in the parent birds which was probably reflected in the reduced laying rate, consequent on a much heavier than normal level, earlier in the season. Although this hypothesis is thought-provoking, it should be recalled that F. A. HAYS and E. W. SPEAR (*Poult. Sci.*, 1952, **31**, 792-5) pointed out that with older parent birds more male chicks hatch out than females; with younger breeding stock the reverse applies, but in both instances the sex ratio in the embryos is about 50 : 50. HAYS also showed (ibid., 1948, **27**, 186-93) that viability of Rhode Island Reds showed a decrease as fertility improved. Whether high egg production has an ageing effect, and so can influence the sex ratio, seems speculative.

R.C.

Provincial Note

Winter Feeding in Pennine Areas

C. H. MUDD

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THE PENNINE AREA referred to in this article extends over nearly ¾ million acres of six different counties, and lies between Barnard Castle in the north and Derby in the south. Because of its upland character—600-2,000 ft above sea level—there is a considerable area of rough grazing. There are over 8,000 holdings, mostly between 30 and 40 acres in extent. Some of the land is on limestone, but much of it is millstone grit, and most of the area is covered with boulder clay of glacial origin. Coal Measures are common in the central regions. The soil is generally shallow and of a low pH; available phosphate is usually low. Rainfall is spread evenly over the year and varies between 40 in. on the eastern slopes to 80 in. on the higher western hills, causing rapid leaching of plant food, as well as serious land drainage problems. The northerly latitude, high altitude, damp conditions, and lack of tree shelter inevitably result in a long winter, and milk cows are generally housed from September to May. Atmospheric pollution affects the whole area to a greater or lesser degree, for it is the centre of an intensive industrial region, whose population is over 5 millions. Deposits of soot cover leaves; heavy concentrations of sulphur dioxide in the area undoubtedly have a deleterious effect on plant life, and probably cause ill-health in livestock. The perpetual smoke haze reduces sunlight and probably lessens photosynthesis.

Hill Sheep Farming

An environment such as this encourages the normal systems of hill farming, i.e. hill sheep combined with cattle rearing for dairy replacements and beef stores. However, for many of the more northerly holdings, the turnover is limited by the amount of valley land available for the production of winter keep. In the Yorkshire dales, the narrow valleys—that of the Swale for example—provide only a limited area of meadow land on which to lamb the hill flock and provide winter keep for the cattle, while the area of hill grazing is relatively greater.

It is extremely difficult to increase productivity on the true hill farm and leave a margin of profit, for costs are extremely high, and output relatively low. Nevertheless, production has increased on the fells by gripping and surface drainage, liming, fertilizing and reseeding. The established practice of permanent grass meadows to provide hay for the cattle, and spring and autumn grazing for the sheep, is difficult to improve upon, and the small acreages of arable land which were seen during the

war have almost disappeared. Overhead costs of arable cropping are often too high on small acreages to be worth while.

Recent experiments carried out in the Province have shown that the application of fertilizers to the meadows in spring increased the weight of hay by as much as one third, thus making good the loss incurred through grazing by the sheep in the spring. This line of investigation is being pursued. There is no doubt that the quality of hay made from these meadows in good weather is superb, for it is grown quickly and harvested at an early stage; it contains a high proportion of clover and 'herbs', often analysing 14 per cent crude protein. Weather conditions, however, are often poor during the haymaking season and a moderate quality is more common. The full advantage of tripod haymaking cannot be obtained with this type of meadow hay, because the herbage packs down tightly and prevents the wind blowing through. Traditional methods of haymaking are probably still the best.

Sheep must be hardy to stand up to Pennine conditions, for there is little or no hay to spare for them, and they must forage for themselves on the open moor during the winter. The Rough Fell, the Swaledale, the Lonk and the Derbyshire Gritstone are all adapted to the environment and do not require hand feeding except in the most severe snow storms. Most of the concentrates are saved for the cows in milk; young cattle survive the winter on a diet mainly composed of hay, although a small amount of purchased concentrates is sometimes fed.

The advent of the Milk Marketing Board, and later the stimulus given to milk production during the war, brought many of these hill farms into the liquid milk market, for it provided a quicker turnover than stock rearing and enabled them to purchase feedingstuffs and thereby profitably increase the amount of winter keep available on the holding. It was anticipated that post-war conditions and the switch of emphasis from milk to meat would have resulted in these hill farmers moving back to the rearing of stores, but the attraction of the monthly milk cheque has been strong and many are still producing milk. For those rearing dairy heifers the system fits in quite well, as the heifers can be milked for one lactation and then marketed without depreciation costs.

Some of the large hatcheries have encouraged the establishment of a small flock of poultry on free range for the supply of hatching eggs. This has proved to be quite a profitable sideline and may develop into the keeping of birds intensively for commercial egg production. Pig breeding is another sideline which can be largely independent of soil and climatic conditions, and so long as the price of bacon pigs is tied to the cost of feedingstuffs, good management should result in a margin of profit.

The true hill farmer with a limited acreage in the valley for mowing and a fairly extensive moor- or fell-right is, on the whole, making progress; there is a small profit—admittedly made up of subsidies—to plough back into the land, but provided the farmer is prepared to work hard and to live frugally he can usually make a go of it.

The Smallholding

At the other end of the scale of Pennine farms is the smallholder, concentrating on poultry or pigs, farming only two to ten acres of land. The smallholder's livestock is almost invariably kept on one of the intensive systems, independent of weather and soil; he buys all feedingstuffs required and concentrates upon skilled specialized management of the stock. Although he produces no home-grown feedingstuffs, stockmanship is such that he can still make a reasonable profit. Many breeding flocks for the production of hatching eggs are kept, since the area is the centre of a very large number of hatcheries. Smallholders were particularly hard hit during the war, and many of them were forced to go into industry. Only recently have they been able to re-equip their holdings and expand production.

The Dairy Farm

Most Pennine farmers live in the heavily industrialized region. Their holdings were carved from the hillsides when hand-loom weaving supplemented the farm income, and were consolidated when the Industrial Revolution brought a large population onto their doorstep, creating a heavy demand for milk, meat and eggs. This demand could only be met by the importation of feedingstuffs for stock, but these were cheap and plentiful in the nineteenth century, and intensive farming—intensive in so far as livestock numbers were concerned—became established. The first World War did little to upset the system for, although feedingstuffs were dear, the price of the finished product kept in step, and the absence of rationing meant that they could outbid the rest of the country for available supplies. Proximity to the market was still an important factor and the retailing of produce direct to the consumer left the farmer with a retailer's profit, even if the producer's margin was small.

Today the outlook is very different. Proximity to a market is worth little in an age of pasteurization and rapid transport. Although the farmer now receives more than the pre-war price for his produce, he also pays much more for his raw materials. The farmer who is dependent upon the soil for his living, whether he produces hill sheep or arable crops, is better able to plan his production than his counterpart who is dependent on purchased food, for price movements are extremely difficult to predict and costs of production fluctuate. The Chancellor of the Exchequer has spoken about the heavy drain on the country's resources caused by the purchase of animal feedingstuffs abroad, and has emphasized the need for reducing it. The small size of the farm generally precludes the reduction of livestock numbers and herds are mainly 'flying', few cows staying in the locality for more than two years.

Animal food costs on typical West Pennine farms in 1954 accounted for 67 per cent of the total cost of milk production, 75 per cent for eggs, and 86 per cent for bacon. Clearly any reduction in the cost of livestock feeding would profoundly influence the total cost of production, and cheaper foods or systems of feeding are being sought.

The progeny-testing of pigs will undoubtedly show up the more efficient strains with good food-conversion ratios; the system will doubtless spread to poultry and cattle, but these are long-term projects and quick results cannot be expected. The saving of food through better housing, particularly of pigs and poultry, has received a great deal of attention recently. The use of infra-red lamps for young pigs, and low, insulated houses for fattening are becoming the standard practice. Most poultry are now kept intensively, either in batteries or on deep-litter, and the economics of heating poultry-houses in winter is under investigation. Many of the small farmers have expanded their pig and poultry sidelines since 1953, and have thus been able to keep their heads above water, but new ventures require new capital and this is difficult to come by. Milk production is still the main enterprise on these farms; it is small wonder that a season such as 1954 put many farmers out of business, for they had no reserves.

One possible solution to the problem would be to amalgamate a number of smallholdings into one large economic hill farm which could revert to hill sheep and stock rearing, but this would involve a social revolution and is fraught with political problems. In spite of all the difficulties, there are a large number of small dairy farmers on this type of land who are making progress. They receive only very small returns for the long seven-day week, assisted by their family—but output in relation to area is high and the country's loss would be severe if their contribution to food production ceased. Their greatest asset is a very high standard of stockmanship; they are able to keep their stock comfortable and content; to feed according to a cow's idiosyncrasies; to sense when something is wrong with an animal before obvious symptoms appear, and to give that personal and individual attention which matters a great deal to the dairy cow.

Cheaper Feeding

Where it is desired to reduce expenditure on purchased concentrates, the normal practice on lowland farms is to replace them by home-grown cereals such as oats, but in the Pennines climatic, soil and topographical conditions are such that most arable crops are uneconomic. A possible exception is kale, which is not averse to a moist climate, and will give a very high yield per acre, thereby compensating for the abnormally high cost of cultivation. The only alternative, therefore, is to grow high-quality grass in sufficient quantity to provide for the production ration in addition to maintenance. In summer, grass will provide for most of the milk produced, and when conserved as high-quality hay, silage or dried grass, it will provide part of the production ration in winter. The making of high-quality hay is too dependent on good weather to be worth relying upon, although for part of the crop barn hay drying may help. Grass drying has its limitations because of the high cost of driers, but a number of farmers are making their own small tray driers and this may be one solution.

Ensilage is the most satisfactory method of preserving the grass for winter feed, since little or no capital outlay is needed and the grass can be cut at the right stage. Theoretically, it should be possible to provide for maintenance and 2 gal milk per cow from hay and high-protein silage, but in practice this is seldom, if ever, achieved. The starch equivalent of grass silage, even when well preserved and having a high crude protein content, appears to be lower than is generally believed: although the digestible protein may be high, it requires some concentrated food to balance for milk production. That it is good practice to supplement silage with concentrates has been borne out by experiments at Great House Experimental Husbandry Farm where rations based on silage failed to give results equal to concentrated rations until the silage was balanced with some concentrate food.

The value of the early bite as an aid to winter feeding is important if suitable conditions exist. Early species such as Italian ryegrass or S.24 perennial ryegrass, combined with an early application of nitrogen are sometimes helpful, but generally the weather prevents grasses growing until May, when even the late species start to grow. At times it is possible to obtain an early growth of grass, but after being housed all winter, the cows cannot be turned out into the cold wet winds common in the early spring. Generally, it is more satisfactory to try to prolong the autumn grazing by nitrogenous top dressing in September, and by saving some foggage for autumn use or by grazing kale.

Pennine dairy farmers have had to switch from relatively low grass output and high concentrate feeding to a high standard of grassland farming coupled with a cut in the amount of cake fed. Fertilizers are increasingly used—probably twenty times more than before the war—and they are applied to both leys and pastures to supplement muck, which, by arable standards, is plentiful. The purpose of some of the fertilizers is to replace the fertility formerly provided indirectly by purchased feedingstuffs, but most of it is for additional fertility to grow heavy hay and silage crops. Rotational and strip grazing are now common practices and help to release a larger acreage for winter feed.

The Pennine hill farmer supplies five million townspeople in the immediate vicinity with the greater part of their milk and eggs. His difficulties may be many, but the nation's food larder is the richer for his efforts.

It is regretted that publication of this issue of the REVIEW *has been delayed because of the recent dispute in the printing industry.*

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